Two-Stage Clustering on PCB Image for Automatic Extraction of Test Pad Coordinates

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Brief Background

- A Data Mining Approach on Retrieving Test-Pad Location for Printed Circuit Board Maintenance And Testing
- Establish a Structure & Effective Method to aid PCB Maintenance & Testing Using Data mining Techniques
- Performing Cluster analysis using IBM SPSS Modeler
  - K-Means
  - Two-Step
- Using CRISP-DM Framework

Literature Review

- Data mining approach to identify PCB defects

  Kusiak and Kurasek (2001)

  - Use of Decision Tree to predict solder defects
  - Feasible use of Data mining techniques on PCB maintenance

- Overview of Flying Probe Tester

  Hoenle (2015)

  - Basic Understanding of a Flying Probe Tester
  - Uses X-Y Coordinates as guide for probes

- Automatic Optical Inspection on PCB Using Neural Network

  Fanni (2000)

  - Uses machine learning to recognize contact points on PCB image
  - Machine compares with image reference

Business Understanding

- Printed Circuit Boards (PCBs)
- Main Structure & Key Component of electronics products
- PCB bear the brunt of external forces (Heat, Vibrations, Dropping etc.)
- Damaged PCBs requires troubleshooting by Engineers using a schematic or layout of the PCB.

Business Understanding

- Flying Probe Tester
- Automated solution for Engineers
- Requires Computer-Aided Design data
- Uses X-Y Coordinates

What if there are no schematics or CAD data of the PCB?

Business Understanding

- **Business Objective**

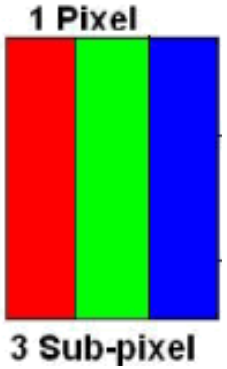
"To aid Engineers in their testing and maintenance of PCBs that do not have schematics or CAD data and to reduce their man-hours needed."

- **Data mining Objective**

"Identify and Locate test-points on the PCB using data mining techniques and to provide CAD data to Flying Probe Testers"

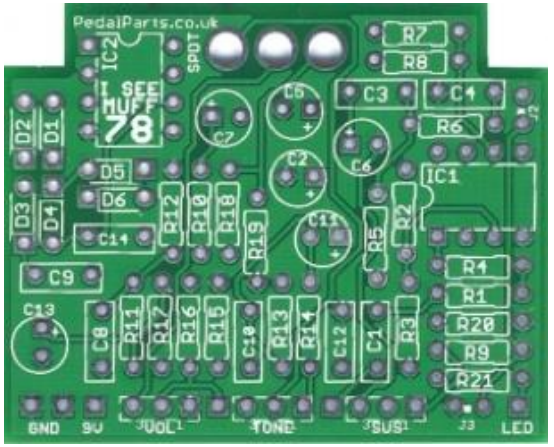
Data Understanding

- Data Source
  - Digital Image of PCB Converted Using Java Script Application



- Variables
  - X-Y Coordinates
  - Intensity of Red, Green, Blue and Alpha (RGBA)
  - Ranges from ‘0’ to ‘255’

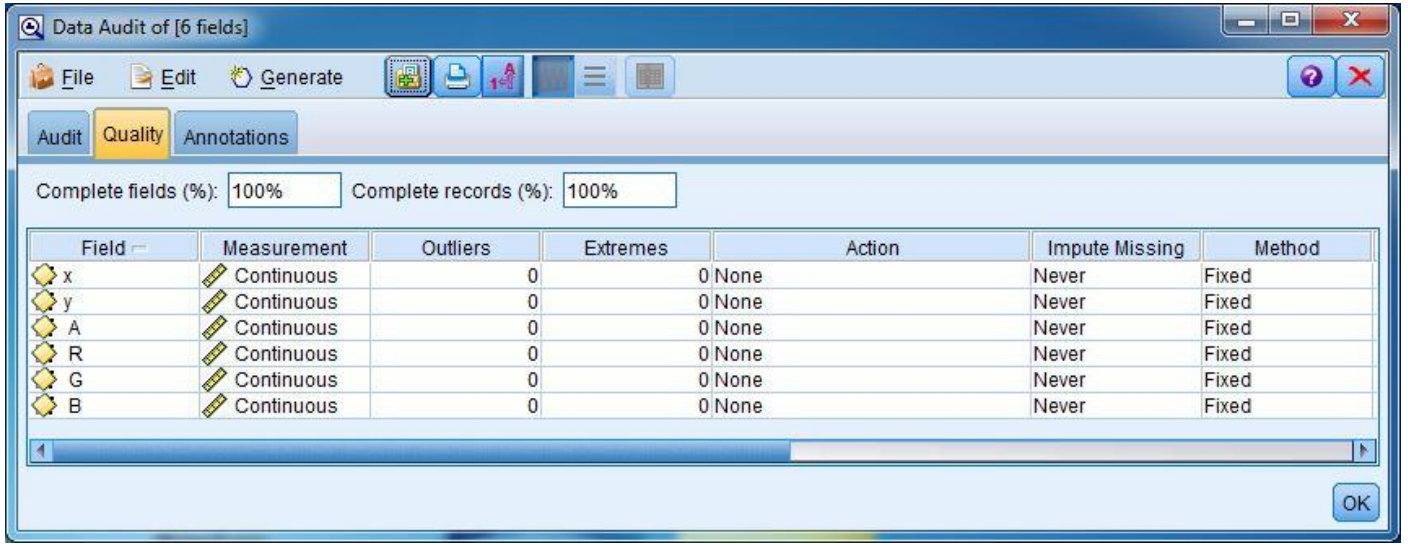
- Each entry represents one pixel on the digital image



- Image has 71,040 pixels

Data Preparation

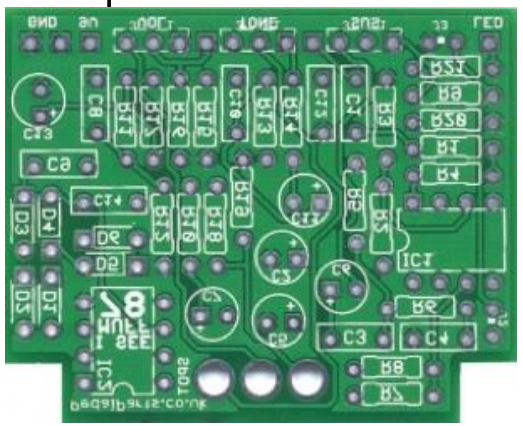
- Data Exploration
  - Very Good Quality
  - No missing values
  - ‘Alpha’ not useful and filtered out



Field	Measurement	Outliers	Extremes	Action	Impute Missing	Method
x	Continuous	0	0	None	Never	Fixed
y	Continuous	0	0	None	Never	Fixed
A	Continuous	0	0	None	Never	Fixed
R	Continuous	0	0	None	Never	Fixed
G	Continuous	0	0	None	Never	Fixed
B	Continuous	0	0	None	Never	Fixed

Modelling

- Modelling Phase Involves 2 Stages
  - Stage 1: Identify Grey Pixels on Image
    - Grey pixels represent the test-pads which the Flying Probe Tester need to contact to test the circuitry of the PCB
    - Grey pixels' RGB values have to be about the same
    - Using a Online Color Picker
  - Stage 2: Creating Test-pad Clusters
    - Cluster the identified grey pixels into clusters of test-pads
    - Using X-Y coordinates of the grey pixels
    - Ideally to have one clusters to each test-pad
    - 120 test-pads on PCB image



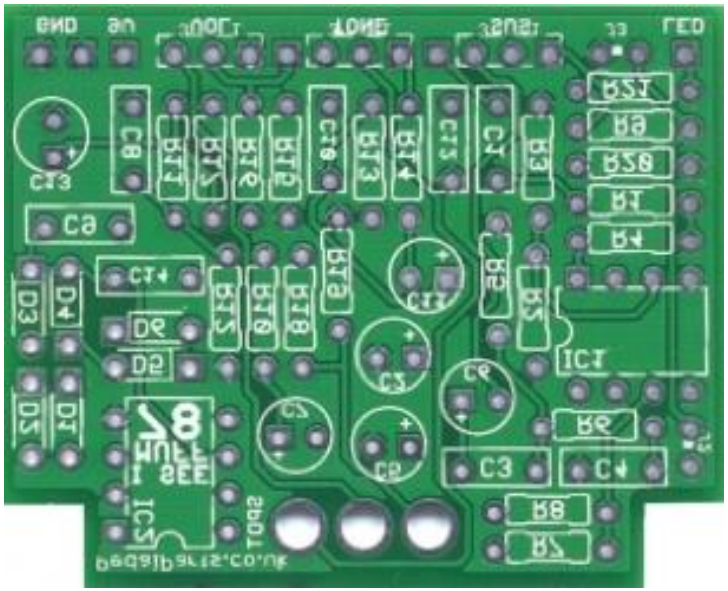
Modelling : Identify Grey Pixels

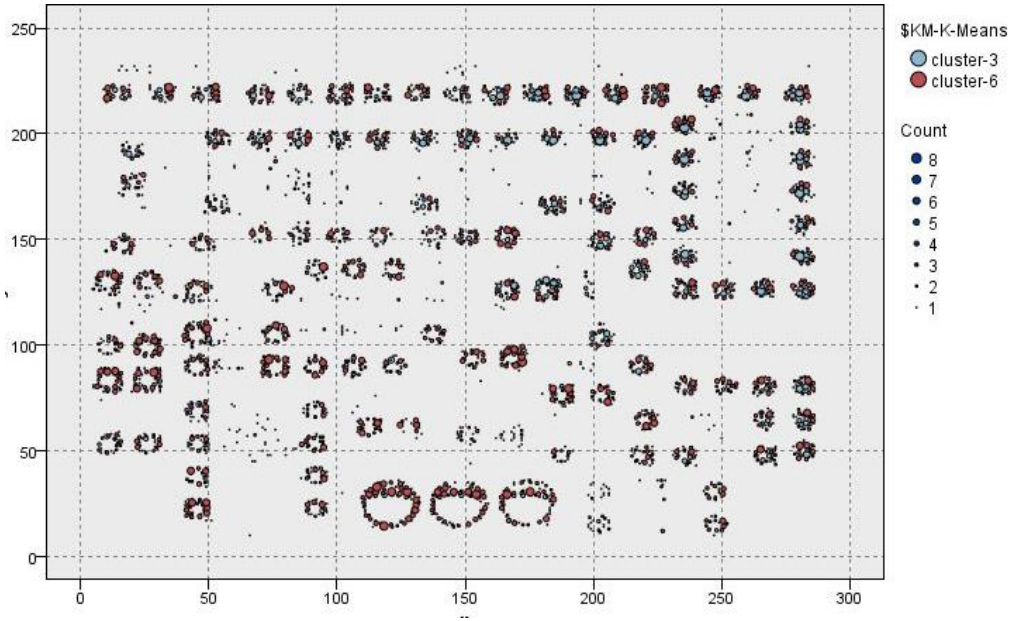
- K-Means & TwoStep model explored
- K-Means found to be best model
- 2 Clusters found with average RGB values close to 'Grey'

cluster-6	cluster-10	cluster-9	cluster-8	cluster-5	cluster-1	cluster-7	cluster-3
Dark Grey	Green	Green	Green	Green	White	Green	Grey
5.8% (4089)	5.4% (3854)	5.4% (3846)	4.8% (3436)	4.3% (3071)	4.1% (2933)	3.9% (2781)	3.1% (2213)
B 114.59	B 118.73	B 223.36	B 174.22	B 197.33	B 252.90	B 142.09	B 152.93
G 112.91	G 146.39	G 246.91	G 189.62	G 221.14	G 254.07	G 175.16	G 146.61
R 92.82	R 95.04	R 205.81	R 153.72	R 178.00	R 250.78	R 120.28	R 131.12

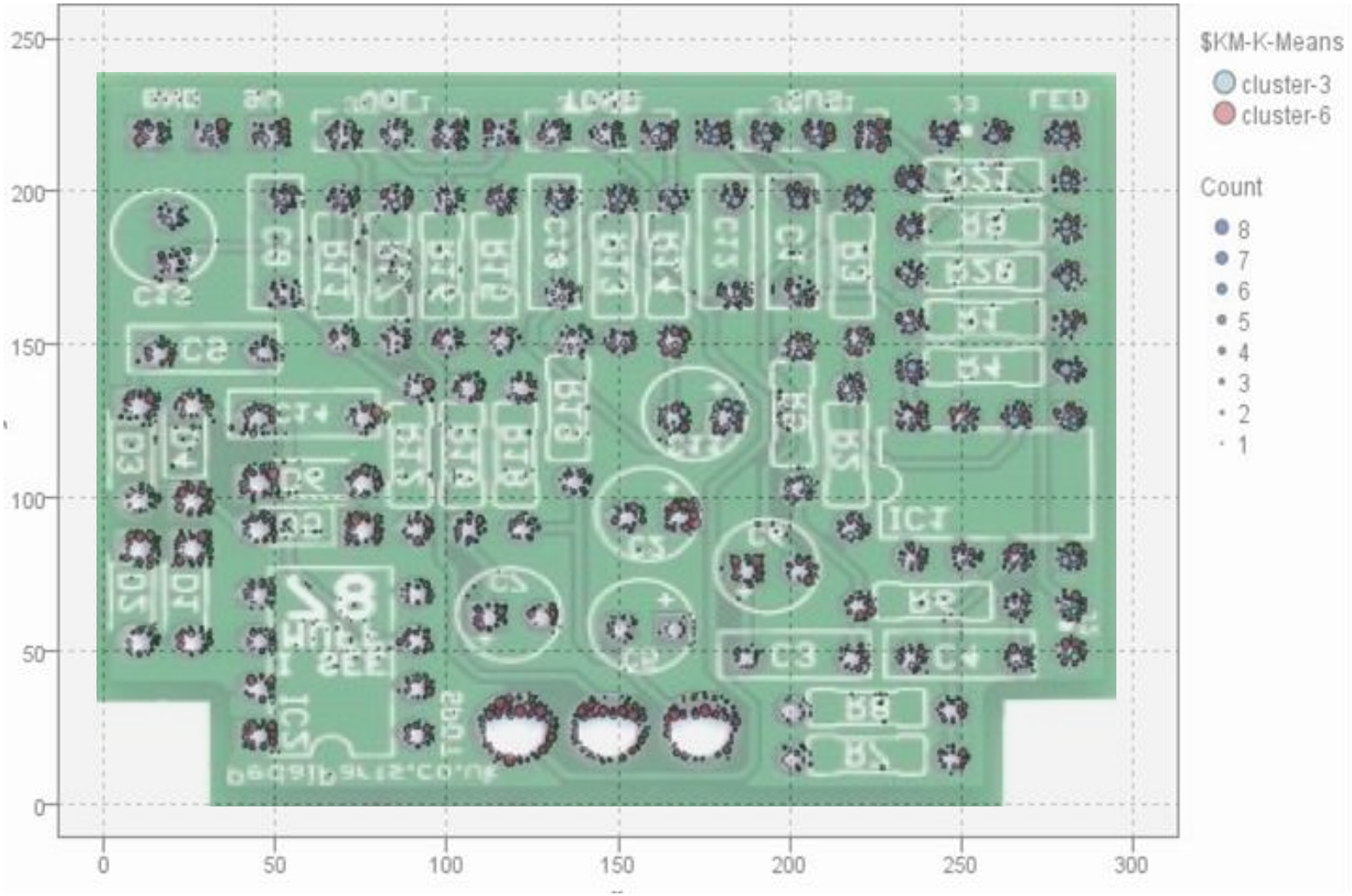
Modelling: Identify Grey Pixels

- X-Y Coordinates of identified grey pixels plotted.



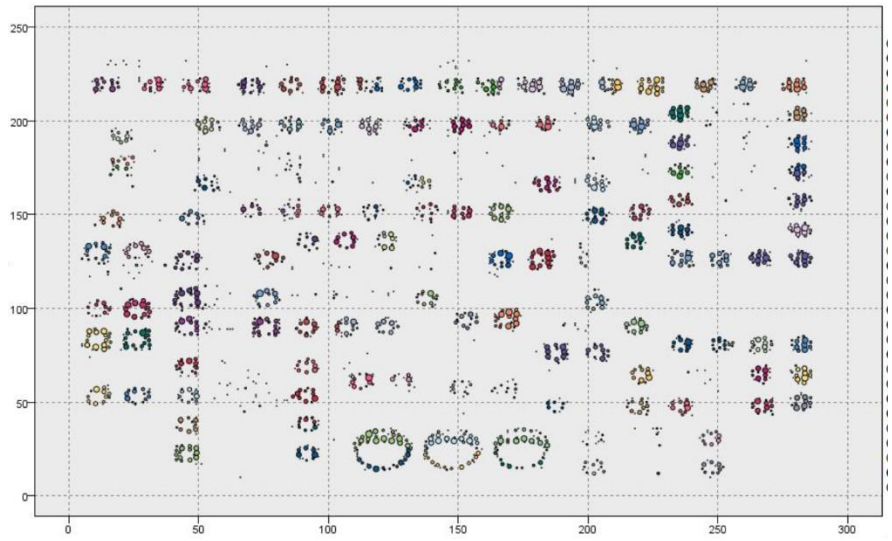


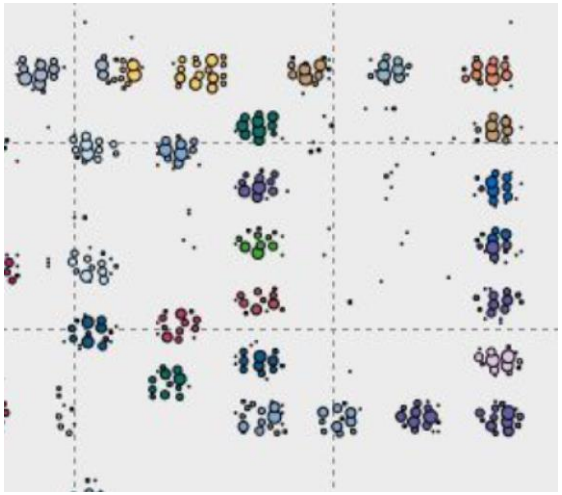
Modelling: Identify Grey Pixels



Modelling: Creating Test-pad Clusters

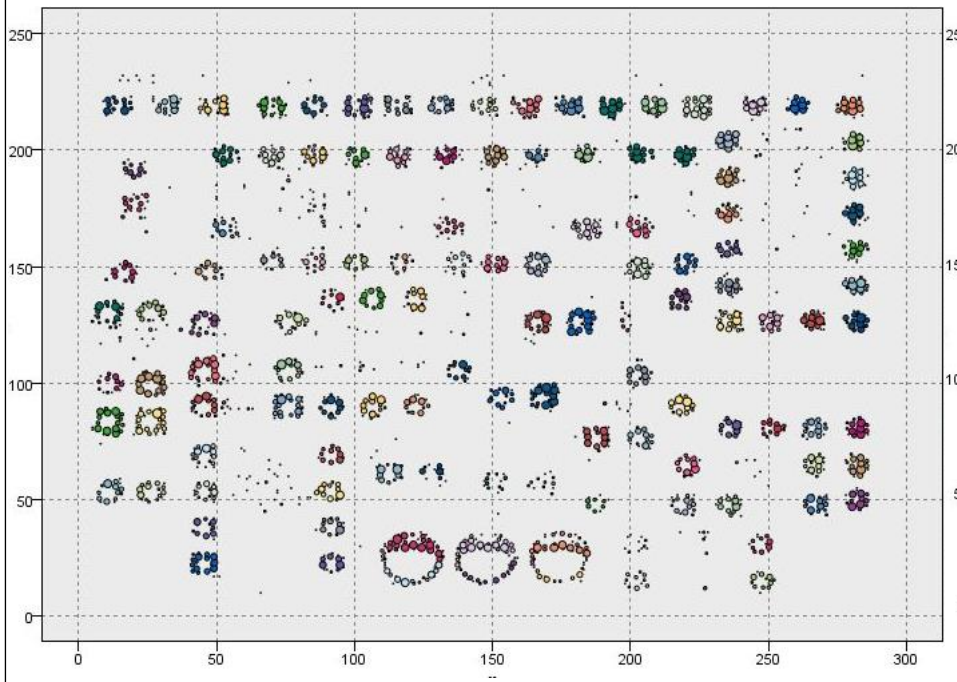
- RGB Values Filtered Out
- Cluster Analysis Performed on X-Y Coordinates
- TwoStep Model found to be best model for task
- To take into consideration sporadic pixels, 170 Clusters created
- Forces model to split up test-pads that are close together

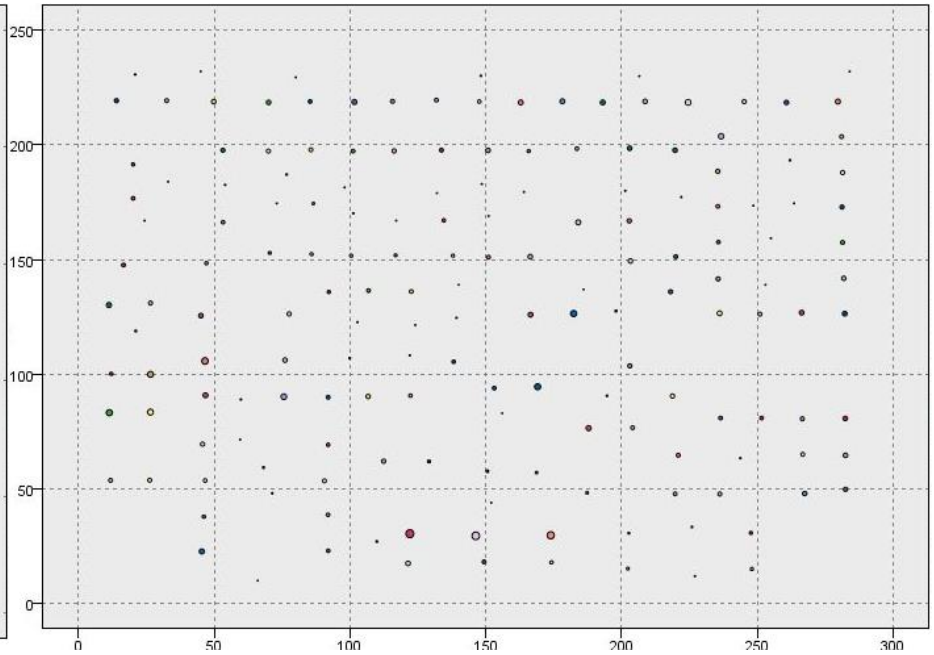




Modelling: Creating Test-pad Clusters

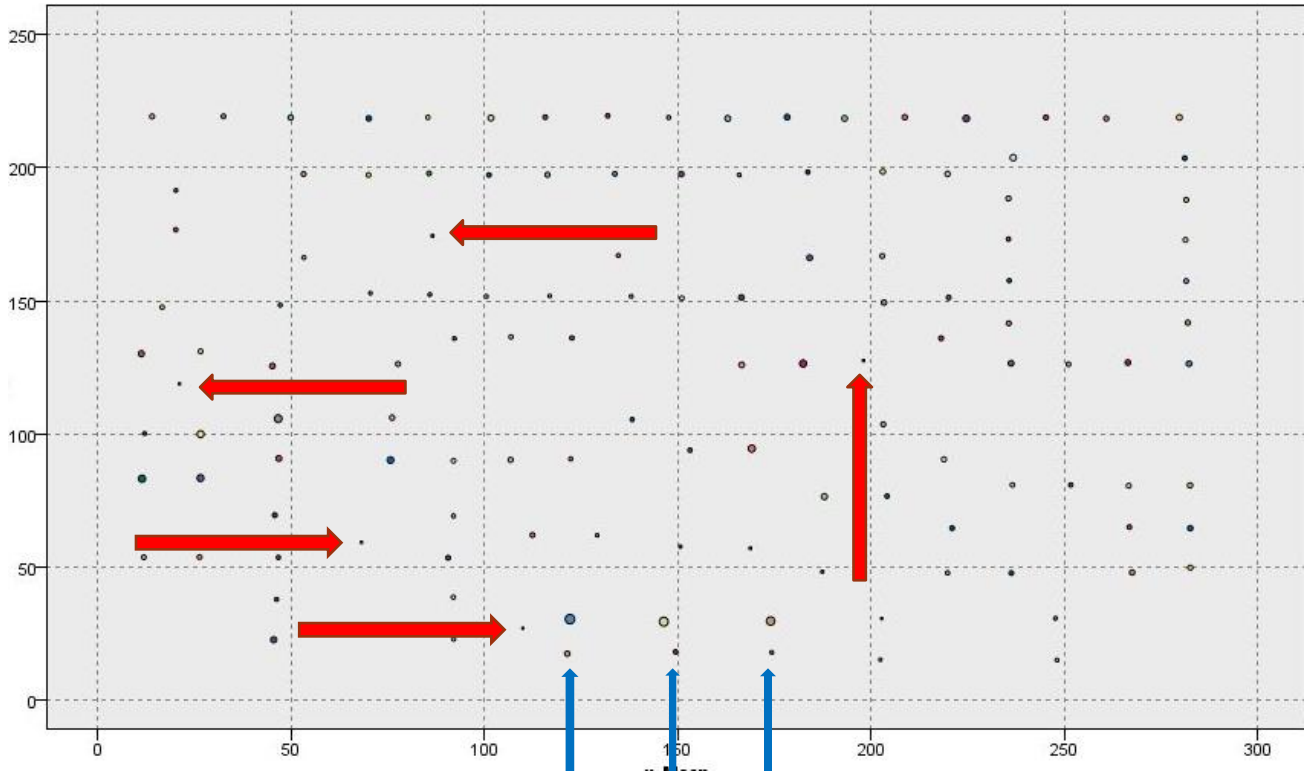
- X-Y values of each cluster aggregated to obtain the mean and center point





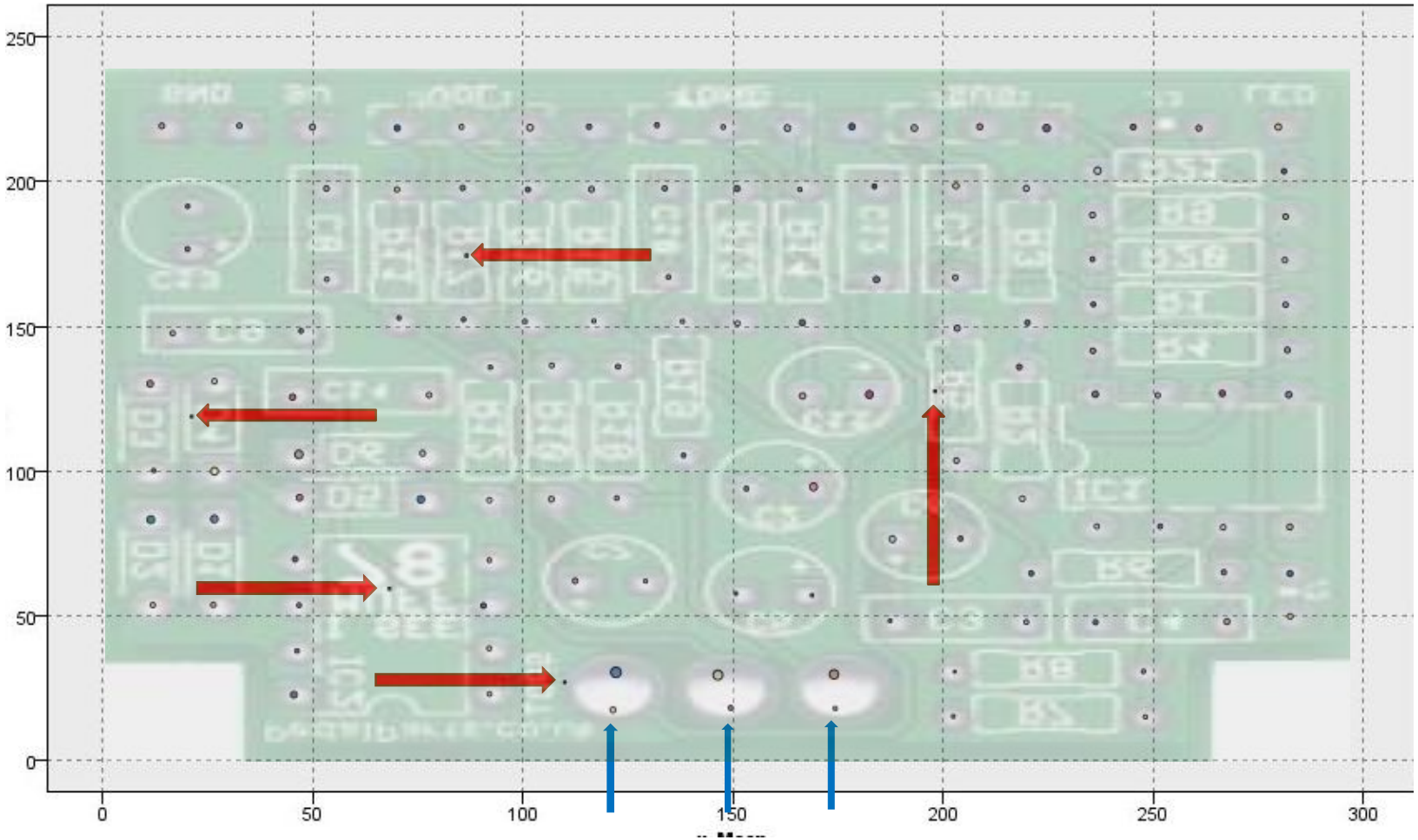
Modelling: Creating Test-pad Clusters

- Clusters with 10 or less Record Counts removed to cleanup non-test-pad related clusters



- 120 Test-pads on PCB
- 128 Cluster points found after cleanup
- Only 5 non-testpad related clusters
- 3 others are duplicates

Modelling: Creating Test-pad Clusters



Evaluation

- Basing on visual reference and comparison, method of X-Y coordinate retrieval is very accurate

- All Test-pads Locations Retrieved
  - 93.75% accurate
  - Remaining 6.25% due to 3 duplicates & 5 non-testpad points

- Error negligible as it only means the Flying Probe Tester contacting on the areas of the PCB which has no test-pad.

Concluding Remarks

- Deployment in Industry
  - Military Electronics
  - Obsolete But Still Heavily Used Equipment
- Potentially save man-hours of Engineers
- Time Focused on the Actual Repair and Maintenance Work
- Potentially integration with AOI Systems

End of Presentation